Fermilab Accelerator R&D Strategy

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DOE Program Review
May 16, 2006

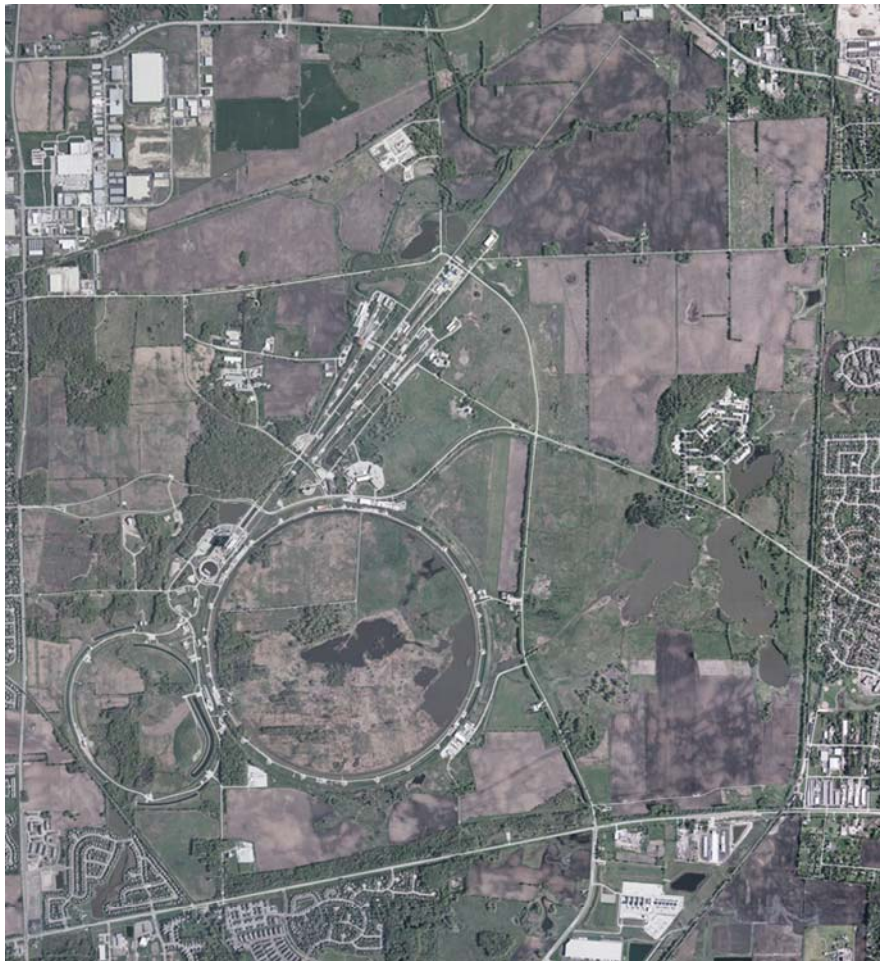
Outline

- Strategic Framework
- Program Elements and Goals
  - LHC/Accelerator Research Program
  - International Linear Collider
  - High Intensity Neutrino Source
  - Muon Facilities
  - AARD at the Photoinjector Laboratory
- Education Programs
- Resources

Note: This presentation does not cover the significant accelerator R&D program that has operated in support of Collider Run II.

Strategic Framework:
Context

- Fermilab has operated the highest energy particle accelerator in the world since 1983. . .
  - This will change in 2007-09
  - Current plan: Tevatron operations will cease on October 1, 2009
- Fermilab currently operates the most advanced long-baseline neutrino program in the world. . .
  - J-PARC will become competitive in 2010-2011



Strategic Framework:
The Vision

- "A strong and vital Fermilab is an essential element of U.S. leadership in elementary particle physics. Fermilab must play a major role in advancing the priorities identified in this report." *EPP2010 Report*

- EPP2010, the Office of Science Twenty Year Plan, and the Fermilab Long Range Plan establish similar goals for Fermilab:
  - Energy Frontier: LHC and ILC
  - Neutrinos: MW class accelerator facility

- Vision includes increased commitment to R&D aimed at the long term future, commensurate with our responsibilities as the U.S. center of accelerator based EPP at the end of the decade

⇒ **Requires an aggressive R&D program accompanied by development of new core competencies at Fermilab.**

Strategy

- Priority to R&D aimed at supporting ILC design and development efforts, and establishing Fermilab as both the world leader in scrf technologies and the preferred host laboratory (Bob K.).
- Commitment to expeditious commissioning and development of upgrade options for the LHC.
- Development of options for enhanced capabilities within the U.S. neutrino program.
  - Proton Plan II/SuperNuMI
  - High Intensity Neutrino Source
- Support for activities aimed at the longer term future.
  - Muon R&D
  - Photoinjector Program

Strategy
Partnerships and Collaboration

All our efforts are now leveraged via (inter)national partnerships

- ILC
  - Strong coupling to the GDE (resources and key people)
  - U.S. center for scrf development, including industrialization
    - Significant help from ANL, Cornell, DESY, INFN, JLab, KEK, LANL, MSU, NIU, Penn, SLAC
- LHC/LARP
  - National collaboration with Fermilab as lead lab: Fermilab, BNL, LBNL, SLAC; close cooperation with CERN
  - Close cooperation in our materials program with UW and NWU.
- High Intensity Neutrino Source
  - National collaboration formed to pursue R&D on the Neutrino Source: Fermilab, ANL, BNL, LBNL, MSU, (SLAC, JLab)

Strategy
Partnerships and Collaboration

- Muon Facilities
  - National collaboration sponsored by Fermilab, BNL, and LBNL
  - Signficant university involvement including (locally) IIT, NIU, UC, UIUC, NWU
- AARD at the Photoinjector
  - Participating institutions include DESY, LBNL, NIU, Rochester, UC, UCLA, UIUC
- ANL-Fermilab MOU on Accelerator R&D Cooperation
  - Illinois Accelerator Day: April 21
- Significant interaction with small business via SBIRs
  - Muons (high pressure absorber; cooling concepts)
  - ILC (cavity fabrication techniques; polarized rf gun)

Program Elements and Goals
Strengthening Core Competencies

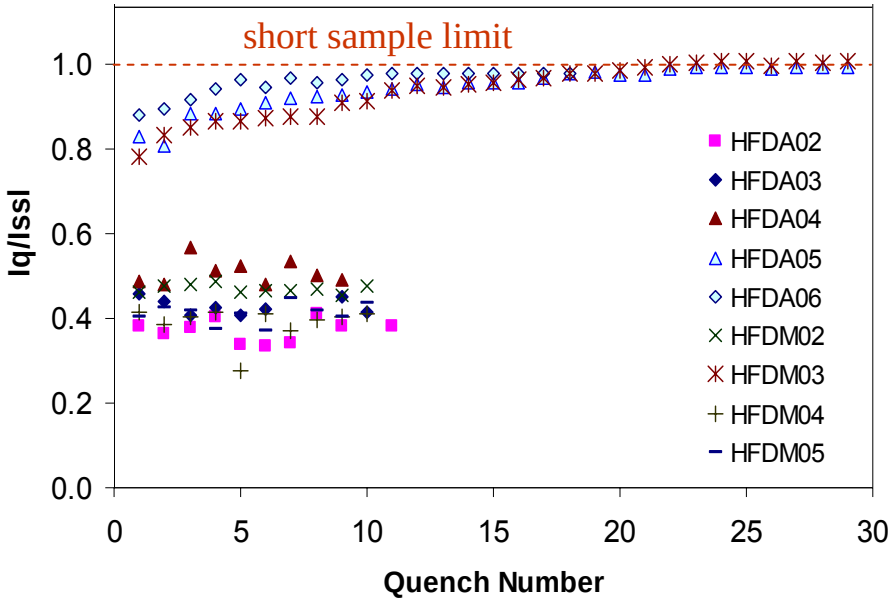
- The main branches within our future rely on superconducting radio frequency acceleration as a technology base.
  - ⇒It is critical that Fermilab establish world-leading expertise.
  - – Has triggered a very significant investment in infrastructure and people
- Fermilab has historically been a/the world leader in superconducting magnet technologies and we will maintain this position for the foreseeable future.
- Accelerator simulations are an increasingly important component in the design of large, state-of-the-art accelerator facilities
  - – We have been a major participant in the SciDAC program and will continue/expand this effort, which is well aligned with future priorities

Program Elements and Goals
LHC/LARP

- Goals:
  - Successfully commission the LHC
  - Demonstrate, by 2010, a Nb_3Sn based high performance quadrupole suitable for utilization in a LHC luminosity upgrade
- Fermilab Role:
  - Fermilab "core program" and LARP are now closely aligned
    - Both programs oriented to quadrupole development
  - Major step forward in last year—identification of conductor instability as potential limitation in Nb_3Sn magnets, and successful solution
  - Major commitment to hardware and beam commissioning
    - Remote control room (LHC@FNAL)

Program Elements and Goals
LHC/LARP

"A major achievement of the HFM group has been their discovery that high performance Nb_3Sn dipole magnet performance can be gravely compromised by flux jump instabilities, which are inherent to all present designs of high-*Jc* Nb_3Sn conductors. This finding, controversial at first, has now been generally accepted. Its implications must be recognized for all high field Nb_3Sn multipole magnet designs. The group is lauded for clearly defining the stability problem in these magnets."
January, 2006 Director's Review



Program Elements and Goals
High Intensity Neutrino Source

- Goals:
  - Execute a plan for reaching ~1 MW beam power based on utilization of current accelerator assets freed up following completion of Run II
    - Proton Improvement Plan aims for 400 kW before end of Run II
    - Recycler as a proton accumulation ring: ~700 kW
    - Antiproton Accumulator as a momentum stacker: >1 MW
  - Develop/demonstrate critical technology elements that could enable construction of a very high intensity (>2 MW) neutrino source when married to ILC developed technologies
    - Acceleration of beam with spoke resonators
    - rf distribution system capable of powering multiple β<1 structures off a single klystron
    - 8 GeV H^- beam transport and MI injection
    - Intensity limitations in the Main Injector
    - Targeting 2 MW beam power

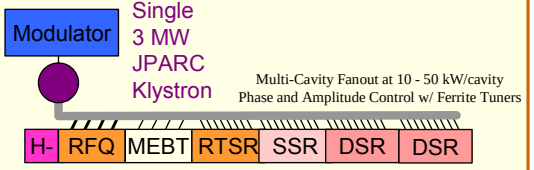
Meson Lab Test Facility: 100 MeV beam in 2009

Program Elements and Goals

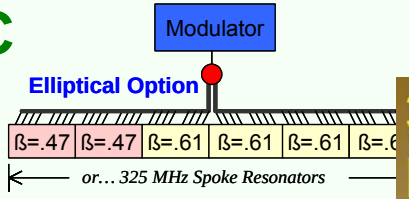
High Intensity Neutrino Source

0.5 MW Initial
8 GeV Linac
11 Klystrons (2 types)
449 Cavities
51 Cryomodules

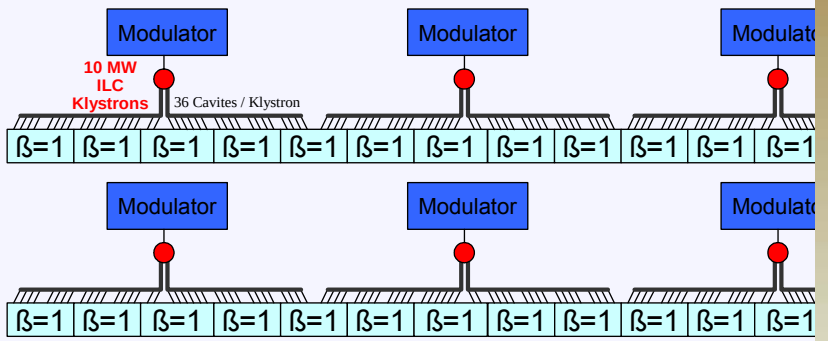
"PULSED RIA"
Front End Linac
325 MHz
0-110 MeV

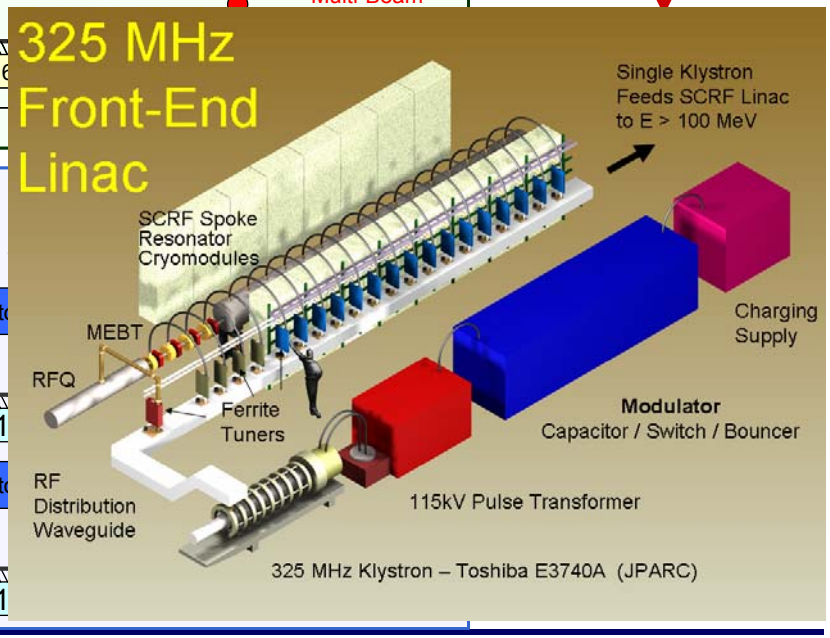


ß<1 ILC LINAC
1300 MHz 0.1-1.2 GeV
2 Klystrons
96 Elliptical Cavities
12 Cryomodules



ILC LINAC
1300 MHz ß=1
1.2-8 GeV





Program Elements and Goals
Muon Facilities

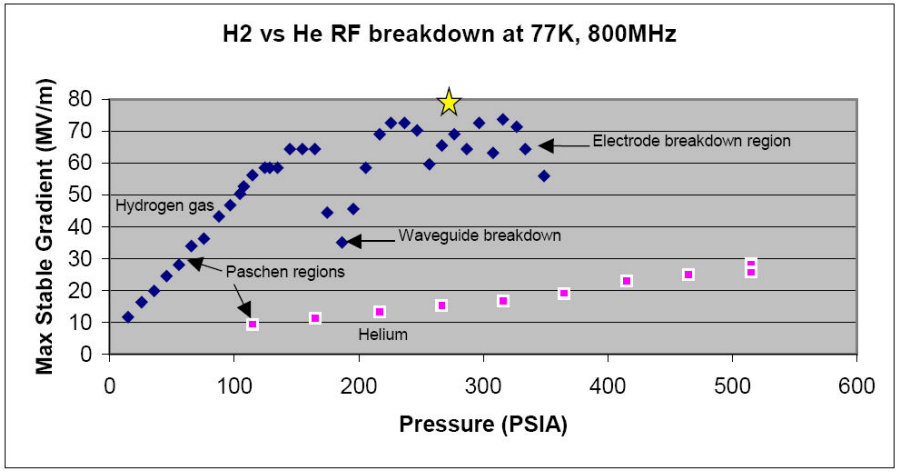
Muon facilities play an important role in our R&D program:

⇒ **May be the only long term path to multi-TeV leptons and/or $\not{CP}$ in neutrino sector**

- Goal:
  - Develop design concepts and demonstrate the critical underlying technologies that could support construction of a muon storage ring as a long term option for EPP
- Fermilab role:
  - Fermilab is host to the MuCool activity, centered around the MuCool Test Area (MTA)
    - Development of technologies for ionization cooling
    - Aimed at the Muon International Cooling Experiment (MICE) at RAL
  - New design concepts
    - Bunch rotation, FFAG acceleration, storage ring design

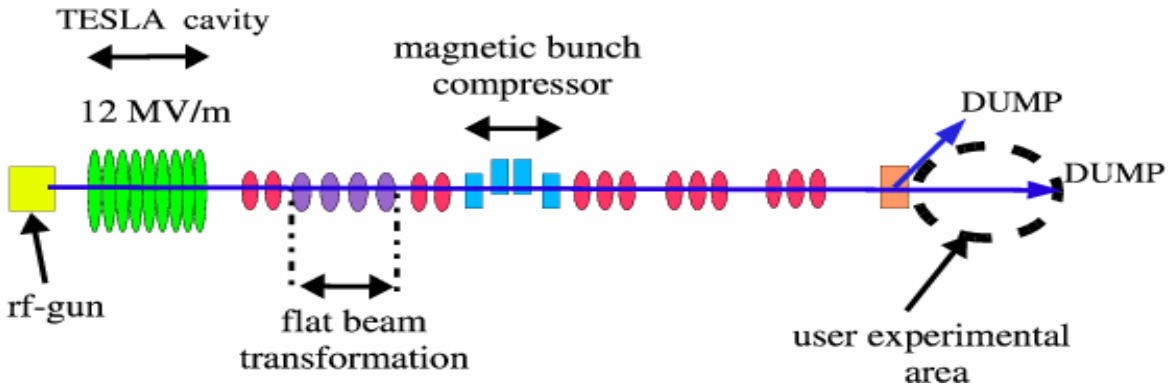
Program Elements and Goals
Muon Facilities: MuCool Test Area

- Facility to test all components of cooling channel (not a test of ionization cooling), with beam
  - Designed to accommodate full Linac Beam (goal: 2007-8)
    - ≈ 600 W into 35 cm LH2 absorber @ 400 MeV
  - RF power @ 201 and 805 MHz
- Program
  - 201 and 805 MHz cavities in magnetic filed
  - Absorbers
  - Cavities utilizing high pressure H_2 (SBIR)



Program Elements and Goals
AARD at the Photoinjector

- Wide variety of AARD programs based on 15 MeV e^- beam
  - Flat beam
  - Plasma wakefield
  - Beam diagnostics
  - ILC DR kicker
  - Polarized rf gun
- Destined to move to ILCTA in 2007
  - AARD will continue in parallel with ILCTA support



Educational Programs

- Accelerator Phd Program
  - Initiated 1984; first graduate in 1987
  - 30 PhD and 1 Masters graduates
  - 26 home universities represented
  - 8 current students
- Fellowships
  - Peoples Fellowship – Accelerator Science
  - Bardeen Fellowship – Accelerator Engineering
- USPAS host
- Joint appointments
  - With IIT and NIU (tenure track level)
- Joint programs
  - Joint ME program in rf under development with NIU

Resources

	Dollar amounts in millions, Direct cost only			
	FY2005	FY2006	FY2007	FY2008
International Linear Collider	$5.1	$14.1	$34.9	$52.6
RF Infrastruture	$7.5	$8.7	$8.3	$12.6
Superconducting Magnets (core)	$2.6	$2.2	$2.3	$2.4
LARP	$0.7	$2.5	$2.5	$2.5
Energy Frontier	$16.0	$27.5	$48.0	$70.0
High Intensity Neutrino Source	$4.4	$10.3	$9.8	$10.1
Neutrino Facilities	$4.4	$10.3	$9.8	$10.1
Photoinjector	$0.5	$1.0	$1.0	$1.0
SciDAC	$1.7	$1.0	$1.0	$1.1
Muons	$1.7	$1.2	$1.6	$1.6
Long Term	$3.9	$3.2	$3.6	$3.7
TOTAL	$24.3	$41.0	$61.4	$83.9

- The message:
  - We are in the midst of a very significant buildup in Accelerator R&D (even more evident if we went back to FY2004: $9.8M)
  - Build up is aligned with the laboratory's strategic vision

Summary

- Fermilab's future requires that we become a world leader in scrf technologies while maintaining our core competency in superconducting magnets.
  - Energy Frontier and Neutrinos
  - By the end of the decade we expect to be the world leader in scrf and in sc magnets
- The program is appropriately balanced between near, intermediate, and long-term while leveraging multiple scrf activities to cover uncertainties in the ILC schedule.
  - The program relies on an extensive collaborative framework involving outside laboratories and universities.
- We are in the initial stages for a very significant buildup in scrf capabilities and infrastructure in support of this program.
- Details in subsequent presentations